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Interaction of Phage-Sensitive and Phage-Resistant Bacteria with Acquisition of Phage Sensitivity

We study a delay system modeling the interaction of phage-sensitive and phage-resistant bacteria in a chemostat. Phage are viruses that attack bacteria. For a lytic phage, the typical infection cycle is initiated by attachment to the host receptor, followed by injection of DNA into the host, and replication of the phage genome. After a latent period, the membrane of the host breaks down, and then the host bursts and releases mature phage.

Most phages can only infect a limited set of strains within a bacterial species. Thus resistant bacteria may emerge. Bacterial resistance is generally due to loss of the receptor molecule to which a phage binds. Because this receptor is involved in bacterial metabolism, the phage-resistant bacteria are usually the weaker competitors than phage-sensitive bacteria for the limiting resource.

Recently Tzipilevich et al. discovered a phenomenon called "acquisition of sensitivity", in which bacteria lacking phage receptors can become transiently sensitive to phage and get infected. This is caused by transfer of phage receptors to the resistant cells, released from phage-sensitive cells, mediated by membrane vesicles. Acquisition of sensitivity implies that the resistant mutant loses more competitiveness than that expected in the literature, so the persistence of the mutant bacteria becomes even less possible. In our work, using persistence theory and the numerical solver DDE-BIFTOOL, we analyze a delay system involving the acquisition of sensitivity to confirm this prediction.